NERVOUS SYSTEM OF PREGENITAL ABDOMINAL SEGMENTS OF TWO ORTHOPTERA (ORTHOPTERA: TETTIGONIIDAE)

JOHN B. SCHMITT
RUTGERS—THE STATE UNIVERSITY
NEW BRUNSWICK, N. J.

RECEIVED FOR PUBLICATION APRIL 9, 1964

Abstract The segmental nerve plan in the pregenital segments of the abdomen in the tettigoniid *Neoconocephalus exiliscanorus* (Davis) anod the gryllacridid *Ceutophilus gracilipes gracilipes* (Haldeman) was found to conform to a pattern previously described in other orthopterous families and in the Lepidoptera, and shares some of its features with the Plecoptera and the Megaloptera.

In an earlier paper (Schmitt, 1954) the writer reported on the segmental plan of innervation of the pregenital abdominal segments of the families Acrididae, Gryllidae, Blattidae and Phasmidae. This paper presents the results of a similar study on the family Tettigoniidae, with notes on a species of the family Gryllacrididae.

The tettigoniid studied was a conehead grasshopper, *Neoconocephalus exiliscanorus* (Davis), specimens of which were collected near New Brunswick, N. J. The gyllacridid or camel cricket studied was *Ceutophilus gracilipes gracilipes* (Haldeman) collected at Mt. Union, Pa., by Mr. William J. Collins. Both species were determined by Dr. Ashley B. Gurney, of the U. S. National Museum.

The abdominal musculature of both *Neoconocephalus* and *Ceutophilus* have been described by Ford (1923) and her descriptions were used as the basis of study. The abdominal nerve cord of *Conocephalus fascinatus* De Geer and *Ceutophilus brevipes* Scudder have been described by Nesbitt (1941). The writer found that *Neoconocephalus* differs from Nesbitt's description of *Conocephalus* in only a few minor details.

1. *Neoconocephalus exiliscanorus*

The abdomen of an adult male of Neoconocephalus is shown in Fig. 2A. The areas encircled by broken lines show the location of the dorsal longitudinal muscles in each segment.

a. VENTRAL NERVE CORD The ganglion of the first abdominal segment is fused with the metathoracic ganglion to form a single ganglionic mass. Connected posteriorly to this combined ganglion by very short intersegmental connectives may be found the first definitive ganglion, itself also a fused ganglion containing the ganglia of the second and the third abdominal segments. This first definitive ganglion is located immediately anterior to the metathoracic furca, and the metathoracic ganglionic mass is slightly anterior to and ventrad to this first definitive ganglion. The ventral longitudinal muscles extending from the metathoracic pleural apophyses to the second

[1] Paper of the Jour. Ser., N. J. Agric. Exper. Sta., Rutgers, The State University of New Jersey, Dept. Ent. and Economic Zool.

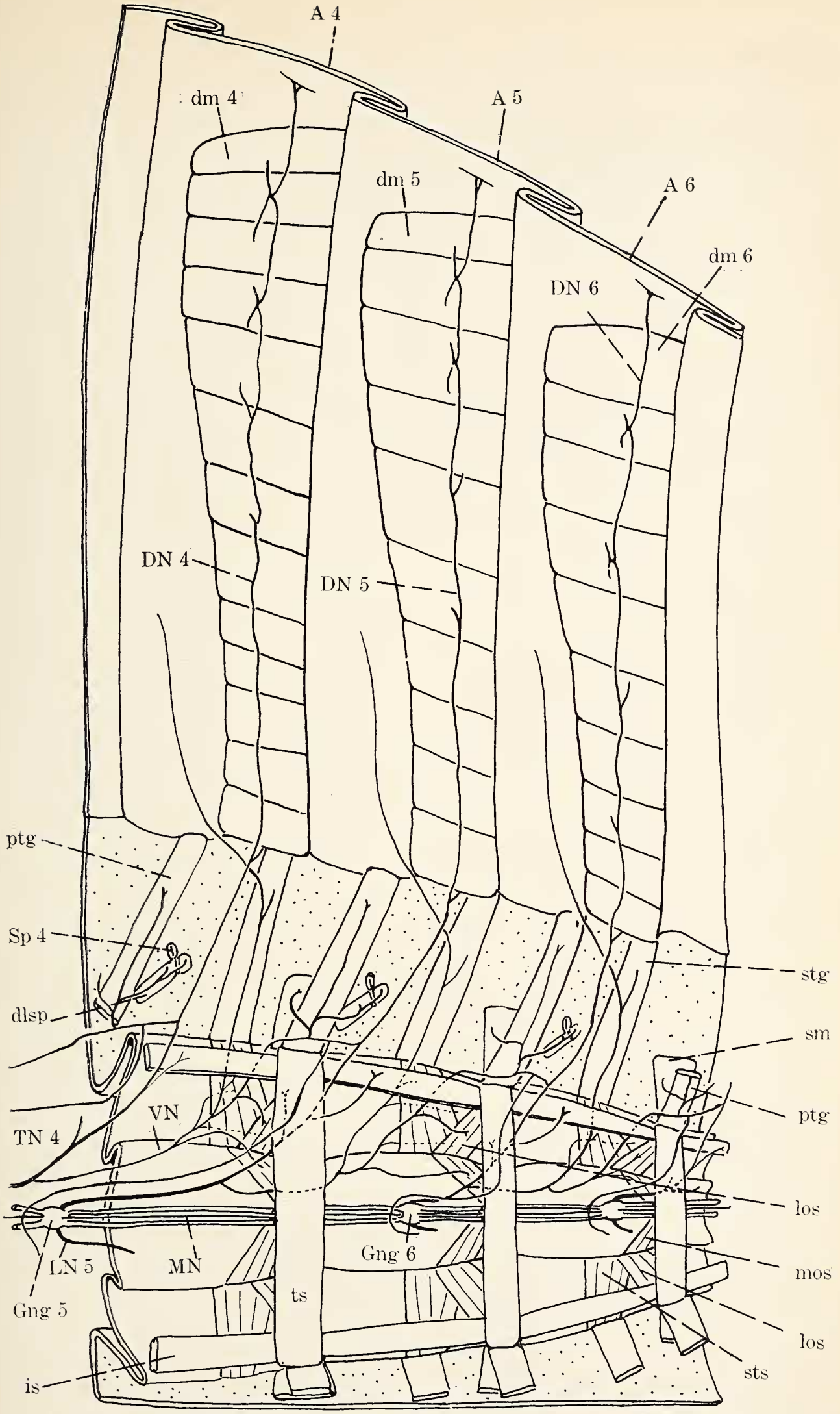

Fig. 1. Mesal view of nerves and muscles of abdominal segments 4, 5, and 6, right side, of *Neoconocephalus exiliscanorus*.

spina partly cover the metathoracic ganglion and must be removed to render the ganglion visible from above.

The second definitive abdominal ganglion, or the ganglion of the fourth

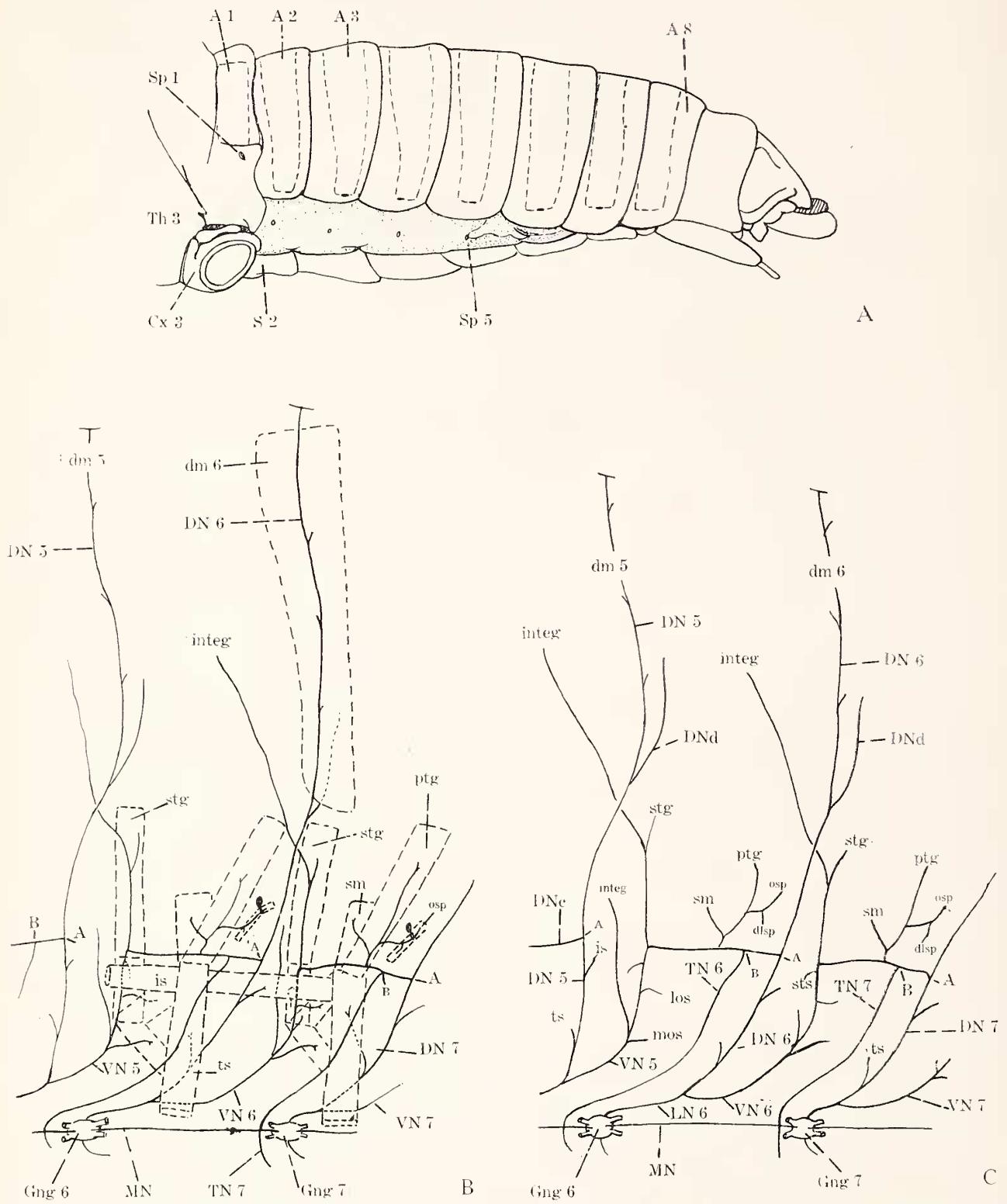

Fig. 2. Abdominal structures of *Neoconocephalus exiliscanorus*. A. Abdomen ♂. B. Nerves and muscles of segment 6, right side. C. Same, with symbols substituted for muscles to clarify innervation pattern.

abdominal segment, is usually located just anterior to the first transverse sternal muscle; and, in similar fashion, the third definitive ganglion or gang-

lion of the fifth abdominal segment lies just before the second transverse muscle (Fig. 1, Gng 5).

The fourth ganglion, or ganglion of the sixth abdominal segment (Gng 6), is usually located midway between the fourth and the fifth transverse sternal muscles. The fifth ganglion (Gng 7) is usually just anterior to the sixth transverse muscle, and the last or sixth ganglion is just posterior to the seventh transverse muscle. The last ganglion supplies nerves to the eighth, ninth, and tenth segments and to the cerci.

b. SEGMENTAL NERVE SYSTEM The distribution of nerves in the right side of abdominal segments four, five and six is shown in Fig. 1. Each ganglion gives off a lateral nerve (LN) which bifuracates to provide a dorsal nerve (DN) and a ventral nerve (VN). This is shown also in Fig. 3A. The lateral nerves from the first definitive ganglion, containing the ganglia of the second and the third segments usually leave the ganglion as a single nerve, which bifuracates to provide the lateral nerves of the second and the third segments; a few specimens, however, were seen in which the segmental nerves emerged from the ganglion as two separate roots. Both nerves pass ventrad of the transverse sternal muscle (ts), which receives innervation from beneath by a branch (Fig. 3, DNa) of the dorsal nerve. The dorsal nerve then passes mesad to the inner sternal muscle (is), which also receives innervation from the dorsal nerve (Fig. 3, DNb). A branch of the dorsal nerve (Fig. 3B, DNc) extending anteriorly is joined by the transverse nerve (Fig. 3B, TN). Continuing anteriorly, the branch DNc becomes in effect a branch of the ventral nerve of the preceding segment. Innervation of the dilator and the occlusor muscles of the spiracle, (Fig. 3B, dlsp, osp), of the paratergal muscle (ptg) and of the sternopleural muscle (sm) is also provided by this nerve complex. Continuing dorsally above the branch DNc, the dorsal nerve provides both mesal and lateral innervation of the dorsal longitudinal muscles (dm), and ultimately terminates on the lateral nerve of the dorsal vessel, as first described in the cockroach by Alexandrovicz (1913).

The ventral nerve, after passing posteriorly beneath the transverse sternal muscle, varies somewhat in its manner of branching. The net effect, however, is to provide the following branches (Fig. 3A): (1) An anterior branch which forks to provide a dorsal nerve which enters the integument anterior to the secondary tergo-sternal muscle, and a pair of posteriorly directed nerves which enter the sternal integument; (2) a variable system of branches which provides nerves to the median outer sternal muscle (mos), the lateral outer sternal muscle (los), and the secondary transverse sternal muscle (sts); (3) a branch passing laterad of the inner sternal muscle, dorsally along the secondary tergo-sternal muscle (stg), to which it provides innervation, and then, continuing lateral of the dorsal nerve, enters the integument anterior to the dorsal longitudinal muscles (dm); and (4) a

posteriorly extending branch, which may be found just above the inner sternal muscle and joining, as previously described, with the transverse nerve and the branch DNc of the dorsal nerve.

A median nerve (MN) extends between each of the abdominal ganglia posterior to the first definitive ganglion. Transverse nerves (TN) are given off from each median nerve from a point just before the posterior ganglion (Fig. 2, B, C) and pass above the transverse sternal muscle to join the branch DNc of the dorsal nerve, as previously described. In the first abdominal segment, the transverse nerves arise as a pair of very fine nerves from the dorso-lateral surface of the fused ganglia of the metathoracic and first abdominal segments and extend laterally to join a short branch from the

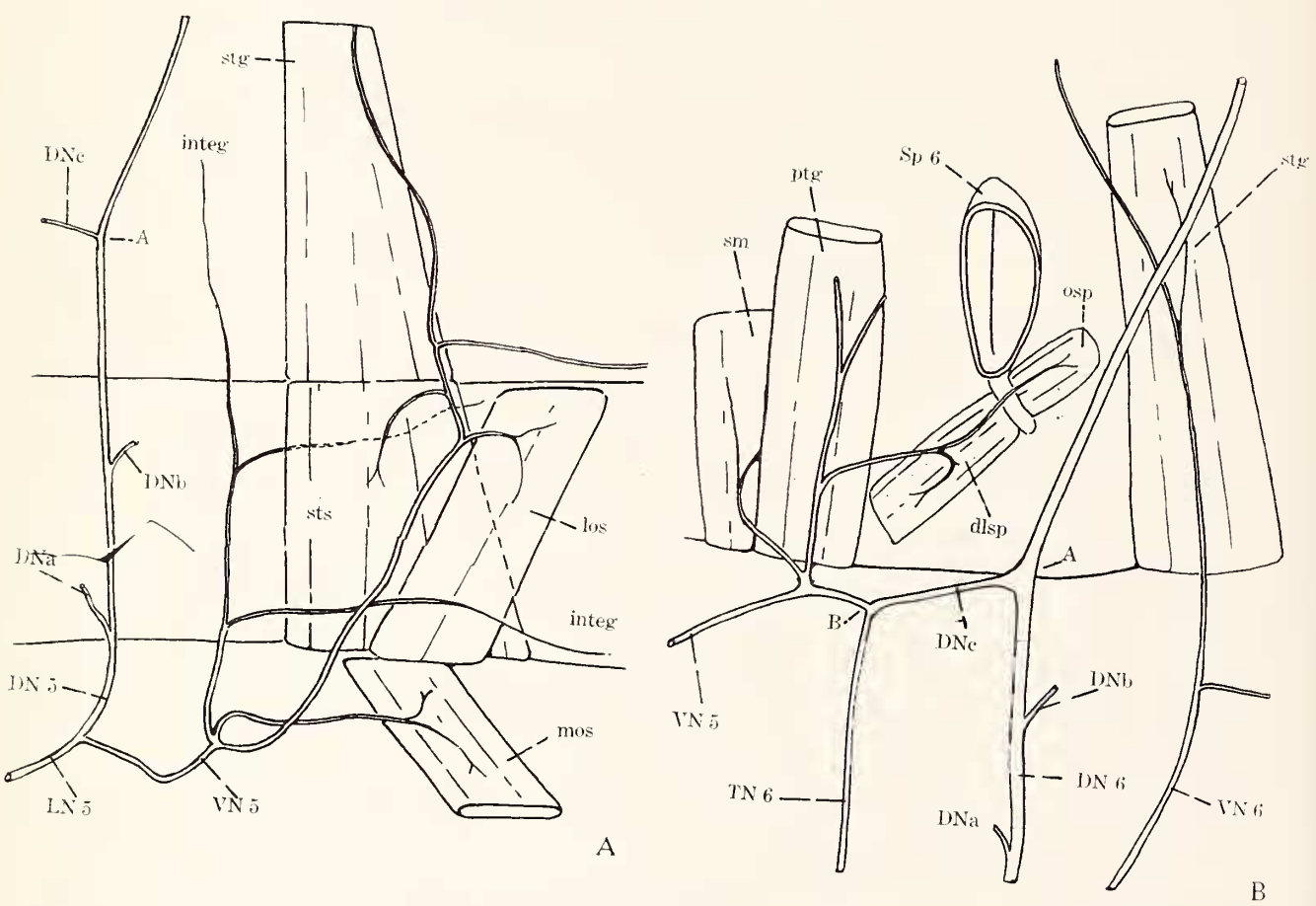

Fig. 3. Abdominal structures of *Neoconocephalus exiliscanorus*. A. Innervation by the ventral nerve, segment 5. B. Innervation of the spiracular muscles, segment 6.

dorsal nerve of the first abdominal segment. Innervation of the occlusor and the dilator of the first abdominal spiracle is provided by a dorsal extension of the common nerve of the transverse nerve joined with the branch of the dorsal nerve. There is, however, no connection with a nerve from the metathoracic nervous system similar to the ventral nerve connection previously described in the posterior, abdominal segments.

The transverse nerves of the second abdominal segments also arise as separate nerves from the dorsal surface of the first definitive ganglion, but in all other respects the nerve plan of the second abdominal segment agrees with

that described above. The transverse nerves of the third segment are given off by the bifurcation of a short median nerve which arises from the dorsal posterior surface of the first definitive ganglion. Nesbitt (1941) shows a median nerve extending between the metathoracic ganglion and the first definitive abdominal ganglion of *Conocephalus*, but this could not be found in *Neoconocephalus*. He shows also two pairs of transverse nerves given off from the median nerve between the ganglia of the sixth and the seventh segments, but only one pair of transverse nerves could be found in *Neoconocephalus* (Fig. 2B).

In the specimens studied, three pairs of sternal muscles, namely the median outer sternal muscle, the lateral outer sternal muscle, and the secondary transverse sternal muscle, were sometimes very weak and poorly developed. This was especially true of the median outer sternal muscle, which was completely absent in some females.

2. *Ceutophilus gracilipes gracilipes*

The segmental nerve plan in the pregenital segments of *Ceutophilus gracilipes gracilipes* was found to agree so closely to that of *Neoconocephalus* that there appears to be no point in describing or figuring it in detail. Two differences in musculature, the presence of a tertiary tergo-sternal group in Ceutophilus, which does not occur in *Neoconocephalus*, and the inclusion of the secondary transverse sternal group in the secondary tergo-sternal group in Ceutophilus does not involve any marked modification of the nerve plan.

DISCUSSION

The physical continuity of a branch of the ventral nerve with a branch of the dorsal nerve of the following segment, as seen in *Neoconocephalus* and in *Ceutophilus*, conforms to a pattern previously described in the Acrididae, the Gryllidae, and the Blattidae by the writer, and in the Phasmidae by Maquardt (1939), who worked on *Carausius*. (On the other hand, the writer failed to find it in *Diapheromera*.) A similar continuity of these nerves was reported by both Beckel (1958) and by Libby (1959, 1961) in the Cecropia moth, *Hyalophora cecropia* (L). Maki (1936), however, found in the megalopteran *Chauliodes formosanus* that this nerve continuity may or may not occur in different specimens. It is not at all clear, therefore, just what purpose is served by this continuity. One objective in undertaking this study of the Tettigoniidae and Gryllacrididae was to learn whether the nerve continuity occurred in these families.

A junction of the transverse nerve with this nerve continuity as found in *Neoconocephalus* and *Ceutophilus* is also characteristic of the Orthoptera, and has been described as well in the Lepidoptera by Beckel (1950) and Libby (1959, 1961), in the Megaloptera by Maki (1936), and in the Plecoptera by Wittig (1955) and Schmitt (1936). In the Lepidoptera, as de-

scribed by Kuwana (1932) and by Libby (1959), and in the Plecoptera (Schmitt, 1963), branches of the transverse nerve provide innervation to the alary muscles of the heart. Although the alary muscles are clearly evident in Neoconocephalus and Ceutophilus, no such innervation could be found, but the termination of the dorsal nerve in the lateral nerve of the heart conforms to published observations on other Orthoptera.

KEY TO FIGURE ABBREVIATIONS

A, point of homology: site of shared branch of dorsal nerve
A1, A2, etc., abdominal segments
B, point of homology: junction of transverse nerve with shared branch
Cx3, metathoracic coxa
dlsp, dilator of the spiracle
dm, dorsal longitudinal muscle
DN, dorsal nerve
DNa, DNb, etc., branches of the dorsal nerve
Gng 5, Gng 6, etc., ganglia of the indicated segment
integ., integument
is, inner sternal muscle
LN5, LN6, etc., lateral nerve of the indicated segment
los, lateral outer sternal muscle
MN, median nerve
mos, medial outer sternal muscle
osp, occlusor of the spiracle
ptg, primary tergo-sternal group
S2, S3, etc., sterna of the indicated segment
sm, sterno-pleural muscle
Sp1, Sp2, etc., spiracles of the indicated segment
stg, secondary tergo-sternal group
Th3, metathorax
TN, transverse nerve
ts, transverse sternal muscle
VN, ventral nerve

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CORRECT DATES FOR BUTTERFLY NAMES DESCRIBED BY WILLIAM HENRY EDWARDS IN THREE ENTOMOLOGICAL PUBLICATIONS

F. Martin Brown[1]

Fountain Valley School
Colorado Springs, Colo.

Received for publication Dec. 12, 1963

Abstract The three journals involved are Proc. Acad. Nat. Sci. Phila. 13, 14; Proc. Ent. Soc. Phila. 1–6; Trans. Amer. Ent. Soc. 1–11. The content and publication dates of each of E's. articles is discussed and a summary in the form of an alphabetical list containing 224 species names given. For each name the date of release of the preprint and the date of publication of the volume part containing the name is given. An informal opinion of the Commission on Zoological Nomenclature establishing the validity of preprints for purposes of priority is quoted.

In the course of my study of the types of butterfly names proposed by William Henry Edwards it has been necessary to investigate the dates of publication usually associated with each name. Precise dates of publication for the various parts of the Proceedings of the Academy of Natural Sciences of Philadelphia were published by the Academy in 1914 in the "Index to Journal and Proceedings of the Academy of Natural Sciences of Philadelphia, 1812–1912." Dates for the various parts of the Proceedings of the Entomological Society of Philadelphia were published by me (1964), and those for the Transactions of the American Entomological Society, Volumes 1–10, are in press (Brown, 1964a).

These three journals have in common a bibliographic problem that may

[1] This study was supported by N.S.F. Grant GB-194